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New Types of Broadband Providers Had a Substantial Impact on FCC Broadband Internet Auction for Underserved Communities

According to a 2020 Federal Communications Commission (FCC) report, 18.3 million Americans still lack access to broadband internet. As part of its Rural Digital Opportunity Fund (RDOF) efforts to bring fixed broadband and voice service to these millions of underserved homes and businesses across the US, the FCC conducted Auction 904 – RDOF Phase I – from October 29 to November 25, 2020. The RDOF auction awarded $9.2 billion in subsidies to broadband internet service providers (ISPs) that committed to offering broadband service in underserved areas at or above certain speed/latency thresholds. The subsidies will help bring high-speed broadband to over 5.2 million homes and businesses.

Notably, one of the auction's more successful bidders was SpaceX's low-earth orbit (LEO)-based Starlink ISP, which was awarded about 10% of the total subsidies in the auction. However, because SpaceX's satellite-based network infrastructure and deployment cost structures are fundamentally different from those of traditional fixed wireline ISPs, its choices when bidding for cost-of-deployment subsidies differed substantially from those of wireline ISP bidders. Those structural differences may have made an impact on the auction's final outcome.

How the RDOF Phase I auction worked

RDOF Phase I was a multi-round, descending clock auction. In each round, ISPs bid on the opportunity to provide broadband connectivity with a certain quality of service to a given coverage area, in exchange for receiving a percentage of a predefined benchmark subsidy amount (the "reserve subsidy"). The subsidy percentage decreased with each subsequent round. This "clock percentage" decreased until aggregate bidding amounts were within the $16 billion budget of the auction, at which point subsidies for different areas began to be awarded to winning bidders.

These rules gave preferential treatment to bidders that would commit to providing high-quality gigabit service speeds in two ways.

1. Lower-quality ISPs' bids were weighted downward. For example, a bidder might only receive 50% of the benchmark subsidy amount for an area when the clock percentage was at 70%.

2. Once aggregate bidding was within the total budget, lower-quality ISPs could no longer compete with higher-quality ISPs even if they were willing to accept a smaller subsidy. Since SpaceX did not commit to gigabit service speed, their bidding was disadvantaged relative to gigabit ISPs.

Novel infrastructure bidders' impact on the auction

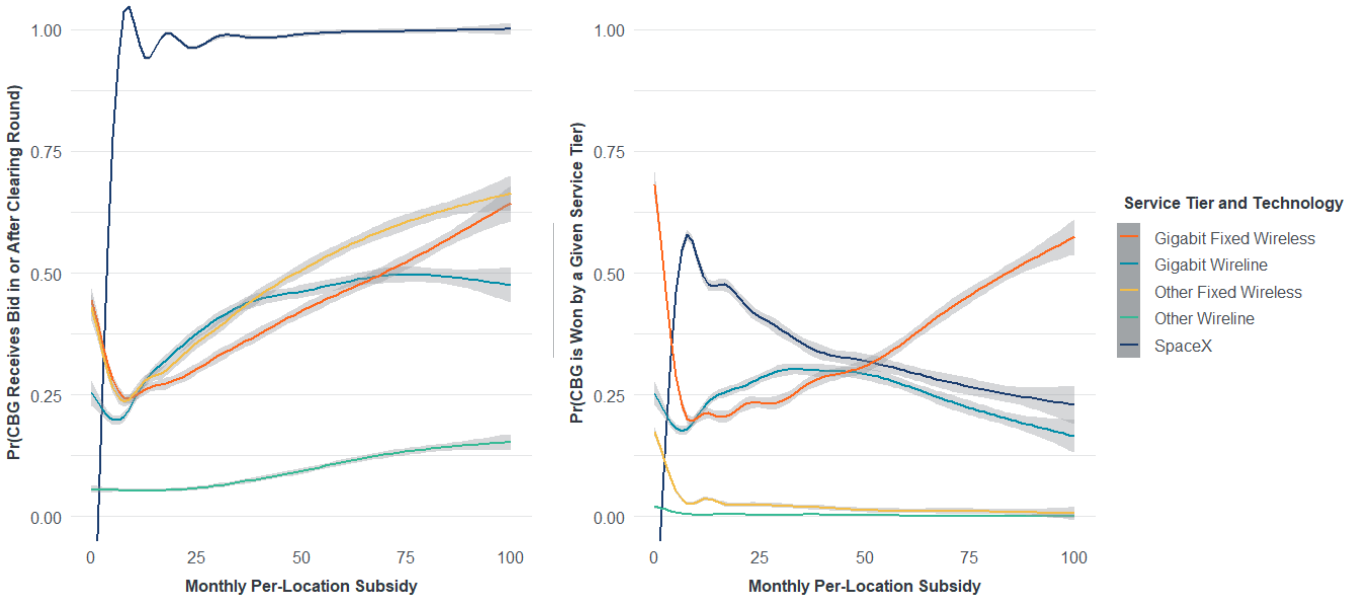
Brattle economists Dr. Coleman Bazelon, Dr. Paroma Sanyal, and Dr. Jonathan Lee authored a white paper discussing what we can learn from the auction's outcomes, *Novel-Infrastructure Bidders' Impact on Cost-Based Subsidy Auctions: Evidence from RDOF Phase I*. The first chart below (from the white paper) shows that wireline ISPs (blue lines) and fixed wireless ISPs (green lines) were less likely to bid on areas with a low subsidy offer, but SpaceX (black line) was willing to bid almost everywhere.

The second chart shows that SpaceX was able to outbid other competitors that did not offer gigabit service (as evidenced by the dark blue and green lines near zero), likely due to its advantageous cost structure. However, SpaceX did lose to higher-quality gigabit bidders (as evidenced by the decreasing black line and increasing light blue and green lines) due to the auction's preferential rules; this was the case even though SpaceX was willing to accept a smaller subsidy.

Brattle's economists used the auction's results to gain insight into the additional cost incurred by the FCC for their preferential treatment of gigabit service ISPs. Absent the preferential rules, the FCC could have secured service commitments from SpaceX at lower costs, albeit with lower-speed service. Preliminary calculations indicate that the potential cost of this preference was at least $2.6 billion over ten years, or 28% of the auction's total awarded subsidies. These insights may prove useful for designing future auctions.

The Brattle team presented their findings at the 2021 TPRC Conference and at the FCC Office of Economics and Analytics' Economics Seminar series. The white paper is available on SSRN.

View the white paper



Spectrum Auction War Games — With Robots

The largest and highest-grossing auction in the history of Federal Communications Commission (FCC) spectrum auctions – Auction 107, or the C-Band auction – closed on February 24, 2021, after raising a jaw-dropping $81 billion in gross bids for the US Treasury.[1] Understanding how bidders behaved in this auction may hold important future lessons for academics, practitioners, industry watchers, and even the mildly curious about spectrum value, strategic bidder dynamics, and auction design.

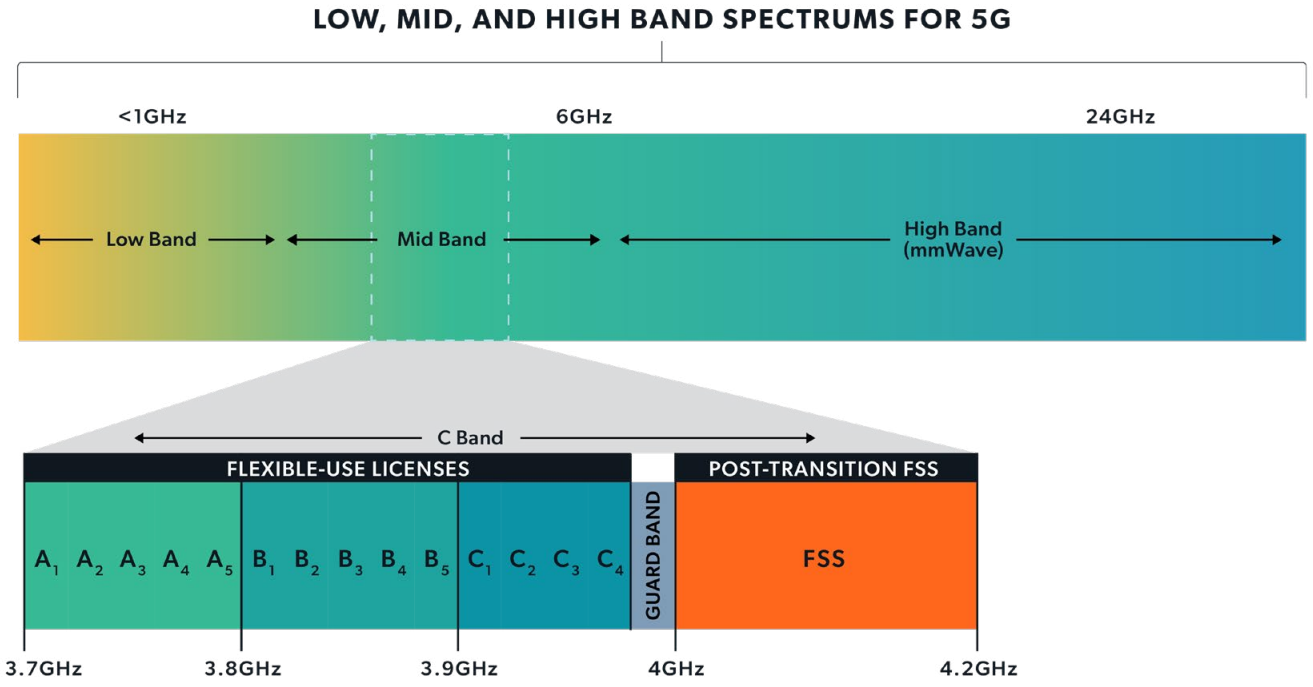
What is the C-Band and why is it so valuabe?

Before we dive in, though, it's important to explain exactly what the C-Band is: The C-Band refers to a part of the electromagnetic spectrum that sits between 3.7–4.2 GHz.[2] Traditionally, the band was occupied by satellite operators and was not considered important for terrestrial mobile services until 5G began to be rolled out. 5G technology uses different kinds of spectrum bands compared to the traditional 3G/4G/LTE architecture , which primarily relies on spectrum below 2 GHz. As a result, the C-Band is now viewed as critical for 5G mobile deployments. The FCC increased the total inventory of spectrum available for mobile use in the US by 34% through its first auction of this band in 2020.

For bidders, participating in an auction can be a daunting mission, with millions and even billions of dollars on the line. (Sharing about the quantity of TUMS required while participating in one of these auctions, Dr. Coleman Bazelon, Brattle Principal and Co-Leader of the Intellectual Property practice, offered useful insights during a recent Planet Money podcast.) The 2020 C-Band auction was particularly complex due in part to the acceleration payments to incumbents, the amount of spectrum at play, and the auction structure.

Building a practical spectrum auction simulation and training tool

For all FCC auctions, the Telecom Group at Brattle builds an auction analysis tool to demystify the auction process and make participation less daunting for bidders in future auctions. A part of this tool is an auction simulator that can



assist bidders in understanding the auction process and the consequent application of game theory required while bidding in these high stakes auctions. The idea is to allow potential bidders to repeatedly play against hypothetical virtual bidders with different preferences, risk tolerances, strategic incentives and budgets. We built the C-Band simulator prior to the auction, complete with a user interface that mimicked the actual FCC auctions and a bid processor that cloned the FCC processing rules.

With the interactive components out of the way, we needed to populate the simulation with bidders. To do this we generated virtual robots (i.e., hypothetical auction participants), and discussed and debated how one should program their bidding behavior. We wanted to balance realism and flexibility in the robot's behaviors. Realism, because we wanted our robots to be acting reasonably (for example, you want robot Verizon to bid as if it wants a nationwide footprint as it did in past auctions), and flexibility because you want the robot to be able to deviate from observed behavior from previous auctions (you don't want robot Verizon to act exactly like it did in previous auctions, because states of the world can change).

We programmed the robots to form bids by maximizing the sum of perceived value for each license – a standard optimization goal for value-focused bidders. Perceived value was estimated for each spectrum license using prior auction data and econometric modelling. With some tweaking, troubleshooting, and debugging, our simulator quickly became playable and it worked like a charm!

Showtime for the simulator

Once the C-Band auction closed, we dug into the more in-depth analysis. To gain insights into how our bidder behavior modeling could be improved, we carried out two modeling exercises.

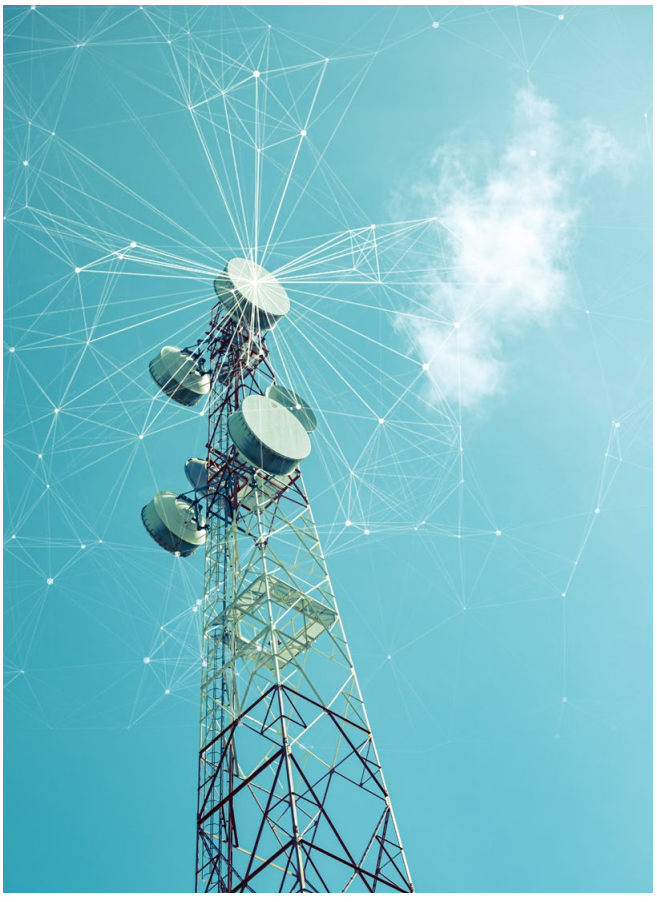
1. We calibrated our structural model to some key realized auction parameters and simulated an auction to see how similar the robots behaved to the real bidders.
2. We fit a machine-learning model that was agnostic about our structural assumptions to the very granular bidding data from the realized auction.

Our findings were interesting, although not entirely surprising. The structural model allowed us to add features we would want to explore as potential bidder behavior and incorporate market intelligence into robot preferences. For example, if industry reports suggest that a bidder is likely to be much more aggressive in an upcoming auction, we could tweak the model parameters to generate that behavior.

The machine-learning model performed very well when predicting historical in-auction behavior as compared to our structural, value-maximizing model. However, unlike the structural model, the machine-learning model was bound by the bidding behaviors it observed in the past auctions and could not generate the "curveball" scenarios that may come up in future auctions.

We presented our findings on this practical simulation tool in a poster session at the Telecommunications Policy Research Conference's (TPRC's) 2021 Annual Research Conference on Communications, Information, and Internet Policy.

For future FCC spectrum auctions, we plan to combine the insights from these two methods to harness the benefits of both modeling approaches. And, do not worry, there is no plan to make these robots self-aware (yet)!



ENDNOTES

1 S&P Global Market Intelligence, "US C-band auction becomes world's costliest mid-band 5G auction yet." https://www.spglobal.com/marketintelligence/en/news-insights/research/us-c-band-auction-becomes-worlds-costliest-mid-band-5g-auction-yet

2 https://www.fcc.gov/auction/107/factsheet

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